

# GERMPLASM IMPROVEMENT AND AGRONOMIC DEVELOPMENT OF NEW ALTERNATIVE INDUSTRIAL CROPS

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## **GERMPLASM IMPROVEMENT AND AGRONOMIC DEVELOPMENT OF NEW ALTERNATIVE INDUSTRIAL CROPS**

### **MISSION**

To acquire and characterize germplasm of guayule, lesquerella, vernonia, and other promising new, alternative crops. To evaluate and enhance germplasm of new crops for industrial raw materials. To develop knowledge of floral biology and seed production and plant responses to stresses. To develop economical, cultural and seed production systems for new crops under various conditions. To develop methods for efficient guayule latex extraction and seed oil analyses for characterizing latex, resin, and oil properties.

## GUAYULE LATEX, RUBBER, AND RESIN

F.S. Nakayama, Research Chemist; T.A. Coffelt and D.A. Dierig, Research Geneticists;  
and S.H. Vinyard and A. Faber, Research Technicians

**PROBLEM:** Termite and wood-rot damage are multibillion dollar problems in the United States. Conventional preservatives used to protect wood from insect and microbial damage are presently of major concern to human health and the environment. Finding alternative and economical preservatives has not been successful. The desert-adapted guayule plant has been observed to have both insect and microbial resistant properties. In addition, the utilization of waste plant material or bagasse, approximately 90% of the total biomass following the extraction of latex rubber from the plant to treat wood, would greatly help the economics of guayule culture.

**APPROACH:** Wood material was impregnated with the resin that was extracted from the guayule plant. Composite boards were fabricated from guayule bagasse material that remained after the extraction of latex rubber. The binders or adhesives used were high density polyethylene (HDPE) and phenolic resin (PR). The two types of wood prepared from guayule were tested for resistance against termite and wood-rot attacks.

**FINDINGS:** Impregnation of guayule resin into wood at 50% by weight and higher is needed to make the wood resistant to termite attack (Table 1). When the wood was impregnated at the 97% resin content level, complete termite mortality was achieved.

**Table 1.** Eastern subterranean termite resistance of southern pine treated with resin extracted from guayule.

Amount of resin extract in wood (%)	Observation (after one week)	Rating (ASTM) <sup>a</sup>
0	Termites still alive	No mortality
10.3	Termites still alive	No mortality
51.8	Mildly termite active	Low mortality
97	All termites dead	High mortality
Guayule particleboard (no adhesive)	Mildly termite active	Low mortality
Guayule composite board with 30% HDPE plastic	All termites dead	High mortality
Guayule branch	All termites dead	High mortality

<sup>a</sup> ASTM D-3345 standard

For the guayule composite board with 30% HDPE, 100% mortality occurred. Thus, fabricating composite board directly from guayule bagasse would be a much simpler approach to take than extracting the guayule resin and then impregnating wood to achieve termite resistance.

The guayule particle board without any adhesive had a mild termite activity. Interestingly, the guayule branch material alone was termite resistant causing high mortality. Bultman et al. (1991) had treated wood with a full-strength resin mixture and obtained 100% and higher resin retention in the

wood. Their resin-impregnated wood samples were able to resist *Coptotermes Heterotermes* for 71 months in the Panamanian rain forest, and *Reticulitermes* spp. for 62 months in semiarid Arizona.

The decay resistance of composite board made from guayule bagasse is shown in Table 2. Both the composite board with PR and the particleboard without resin were resistant to *G. traveum* and *P. placenta*. The composite board with 30% HDPE as the binder showed resistance to the two fungal organisms. The guayule board made with no adhesive exhibited the largest thickness change for *G. traveum* (98%) and *P. placenta* (137%). Thus, the guayule bagasse even though it contains resinous material and rubber will need a binder or waterproofing additive to make its wood product water resistant. Unlike the other wood types, the guayule stem alone had moderate resistance to fungi.

**Table 2.** Decay resistance of guayule composition boards and guayule stems.

Board type and stem	<i>Gleophyllum traveum</i>		<i>Poria placenta</i>	
	Weight loss (%)	Rating (ASTM) <sup>a</sup>	Weight loss (%)	Rating (ASTM)
PF resin, 10% 14 mm	13.94	Resistant	19.61	Resistant
No adhesive, 8 mm	19.66	Resistant	23.99	Resistant
HDPE, 30% 11 mm	6.46	Highly resistant	5.68	Highly resistant
Guayule stem (with bark & wood core)	30.28	Moderately resistant	12.72	Resistant

<sup>a</sup> ASTM D-2017 standard

The guayule resin extract when impregnated into the southern pine made the treated wood resistant to fungal attack as shown in Table 3. Resistance to *G. traveum* started at 10.3% resin content and 51.8% for *P. placenta*. At resin contents of 51.8% and higher, the treated wood was highly resistant (*G. traveum*). The activities of other types of fungi such as brown-rot (*Gleophyllum traveum*, *Antrodia carbonica*, *Fomitopsis cajanderi*, and *Lentinus ponderosa*) and white-rot (*Dichomitus squalens*, *Trametes versicolor*, and *Ganoderma* sp.) were also observed to be inhibited by the resin extracted from guayule (Bultman et al., 1991).

**Table 3.** Weight loss and wood-rot rating of southern pine treated with resin extracted from guayule in the presence of fungi.

Amount of resin extract in wood (%)	<i>Gleophyllum trabeum</i>		<i>Poria placenta</i>	
	Weight loss (%)	Rating (ASTM) <sup>a</sup>	Weight loss (%)	Rating (ASTM)
0	58.60	Non-resistant	47.64	Non-resistant
2.6	52.46	Non-resistant	50.98	Non-resistant
10.3	22.42	Resistant	45.00	Non-resistant
51.8	8.69	Highly resistant	36.65	Moderately resistant
97.0	2.95	Highly resistant	11.11	Resistant

<sup>a</sup> ASTM D-2017 standard

The decay resistances of southern pine that was treated with two different types of resin extracts are compared in Table 4.

**Table 4.** Decay resistance and durability of southern pine treated with two sources of resin extracted from guayule.

Source of resin extract	<i>Gleophyllum trabeum</i>		<i>Poria placenta</i>	
	Weight loss (%)	Rating (ASTM) <sup>a</sup>	Weight loss (%)	Rating (ASTM)
Acetone extract only Bultman resin	10.48	Highly resistant	4.64	Highly resistant
	12.89	Resistant	8.29	Highly resistant

<sup>a</sup> ASTM D-2017 standard

Our guayule resin extracted with acetone alone showed similar decay resistance as the resin provided by Dr. Bultman, which was extracted from guayule with a solvent system consisting of both acetone and hexane.

**INTERPRETATION:** The composite board made from 70% guayule fiber and 30% HDPE, the guayule branch, and normally susceptible wood impregnated with 52 to 97% by weight of guayule resin-extract all had antitermitic property. The guayule particleboard with no adhesive showed termite resistant property, but it could not stand high moisture exposure.

The effects of impregnating southern pine wood with the guayule resin-extracts (content of 10.3% and higher) on the decay resistance (10.3% and higher for *Gleophyllum trabeum*, and 51.8% or higher for *Porio placenta*) appeared to be significant. The treated specimens showed greater resistance to *G. traveum* than *P. placenta*. *P. placenta* often causes decay in millworks and in wood situated above ground.

Southern pine wood specimens impregnated with resin derived from either an acetone extract or a combination of acetone and hexane were resistant to the wood-rot fungi. Both the phenolic adhesive bonded and the guayule only particleboard showed good decay resistance property to *P. placenta* and *G. traveum*. The plastic composite board made from 70% guayule and 30% HDPE was highly resistant to both types of wood rotting fungi.

The natural guayule stems and branches with 10 to 15% resin content also exhibited some decay resistance property. Excessive thickness, swelling and specific gravity reduction occurred with the wood made from guayule plant fiber alone where no adhesive was added.

Our preliminary results indicate that the commercial application of the guayule is possible to provide a dependable, renewable, and alternative natural source of wood preservatives. Because the plant is drought tolerant and its derivatives can reduce tree harvest, its cultivation as an alternative crop will help conserve our water and forest resources.

**FUTURE PLANS:** We will continue to find ways to utilize guayule waste materials for pest control including the fabrication of composite and resin impregnated wood products. We plan to develop cooperative studies with other ARS locations who are working with insect control and to establish Cooperative Research and Development Agreements (CRADA) with private organizations to make use of the waste bagasse for making guayule blends with other waste wood to fabricate high-valued, commercially useful wood products.

**COOPERATORS:** K. Cornish, USDA-ARS-PWA, Albany, CA; J.A. Youngquist, USDA-Forest Products Laboratory, Madison WI; P. Chow, Natural Resources and Environmental Sciences, University of Illinois, Urbana IL; D.T. Ray and D.K. Stumpf, Plant Sciences, P.B. Baker, Entomology, The University of Arizona, Tucson AZ.

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## GUAYULE BREEDING AND GERMPLASM EVALUATION

T.A. Coffelt and D.A. Dierig, Research Geneticists; F.S. Nakayama, Research Chemist; and G. Leake, S. Vinyard, A. Faber, G. Dahlquist, and P. Tomasi, Research Technicians

**PROBLEM:** Allergies caused by using latex products from the Heavea source are a serious health problem in certain population groups in the United States, such as health care workers and patients who undergo multiple surgeries. Guayule is the best potential source of hypoallergenic latex to solve this problem. Previous work has shown that natural latex from guayule can be used to make medical products, gloves, and condoms that prevent virus and other pathogen transmission. In addition, guayule can be grown in the Southwestern United States to provide a domestic source of this valuable latex. Currently, the United States imports all of its natural rubber of which about 300,000 metric tons is used for natural latex products. The United States consumes about one third of all natural latex in the world. For guayule to be used in the hypoallergenic latex market, lines with higher latex content that can be harvested in less than three years are needed to replace older lines that require three to five years before harvesting. Thus, high yielding, fast growing, and easy to establish germplasm is needed for guayule to be successful as a viable new crop. Recent research results from this program have also shown that maximum benefits for genetic improvements can be made when selections are done when plants are one or two years old rather than four or five years old. The objective of the current studies was to evaluate the genetic variation among 20 new guayule lines for agronomic and latex characteristics compared to two older breeding lines.

**APPROACH:** Twenty new guayule germplasm lines and two check lines (11591 and N565) were transplanted at The University of Arizona Maricopa Agricultural Center, Maricopa, Arizona, USA on April 6, 1995. Plots were two rows, each 1 m long and 1 m wide. Transplants were spaced 360 mm apart. A randomized complete block design with four replications was used. Plots were irrigated immediately after transplanting and the soil kept moist with frequent irrigations until plants were established. Plants were maintained each year during the active growing season with approximately biweekly irrigations from February through October. Recommended production practices for row crops in Arizona were used to maintain plots during the experiment.

Percentage of plants surviving per plot and plant height were determined one (1996) and two (1997) years after transplanting. Plant width was determined two years after transplanting. All surviving plants in each plot were measured for plant height and width and the mean for each replicate used for statistical analyses. Changes in survival rate of each plot were calculated by subtracting the survival rates for 1997 from the 1996 survival rates. Changes in plant height of each plot from 1996 to 1997 were determined by subtracting the plot mean heights in 1996 from the plot mean heights in 1997. A plant height to width ratio was calculated in 1997. Two representative plants from each plot were selected in 1998 for determining latex content per plant, wet and dry plant weight, chipping losses, latex yield per plant, and latex and plant biomass yields per  $\text{m}^2$ . Wet plant weights were taken before and after chipping to obtain plant biomass yields at harvest and plant weight losses during chipping. The weight loss during chipping was converted to a percent loss by dividing the after chipping weight by the before chipping weight to standardize data across plots. Dry plant weight was determined by oven drying a sample of the chipped plant material at  $60^\circ\text{C}$ . The weight of latex per plant, latex yield per  $\text{m}^2$ , and plant biomass yield per  $\text{m}^2$  were calculated for each plot. Data were analyzed using the Proc GLM procedure in SAS (1988) for a randomized complete block

design. Replications were considered fixed effects and genotypes random effects. Significance among genotype means was determined by analyses of variance and LSD at the P=0.05 level.

**FINDINGS:** Significant variation was found among the 20 lines and two checks for all characteristics (Tables 1 and 2). None of the lines were significantly better than the checks for all characteristics, but five lines were identified that merit further study. G7-14 was the fastest growing line (406 mm tall) the first year and had the best survival rate (99%). A higher latex content per plant occurred in two lines, P3-11 (4.1%) and P10-4 (4.2%), than 11591 (2.4%) or N565 (3.1%). G1-16 had the highest wet plant weight (2.7 kg), and was one of the highest for dry plant weight (1.6 kg) and total biomass yield (2214g/m<sup>2</sup>). The most promising line was N9-3, which had the highest plant dry weight (1.6 kg), weight after chipping (2.3 kg), latex weight per plant (60.3 g), latex yield per m<sup>2</sup> (83 g), and total plant biomass yield per m<sup>2</sup> (2259 g), as well as the lowest percentage loss during chipping (14.8%).

**INTERPRETATION:** Results from this study indicate that variation is available in this germplasm for significant improvements in all characteristics studied through a breeding and selection program. This is the first study on variation present in germplasm lines for chipping loss. Chipping losses can be associated with several factors, but the amount of leaf material in the sample may be the most important. Leaves tend to be lost during the handling and chipping process. Those plants that were higher in percentage of leaf weight may be the ones with higher chipping losses. Another observation that supports this theory is that samples with less leaf material tend to pass more completely through the chipper, thus leaving less residue in the chipper. Data were not collected in this study on leaf weights or residue left in the chipper. Therefore, further tests will be necessary to identify the specific trait(s) responsible for the significant differences in chipping loss observed in this study. Leaves contain very little or no latex. Thus, removal of leaves prior to chipping and/or harvesting may be desirable for a more efficient chipping process that would require less cleaning of equipment. Latex yields reported in this study should be helpful to industry in order to plan the number of hectares to plant for meeting latex production needs.

**FUTURE PLANS:** An Initiative for Future Agriculture and Food Systems grant was obtained by the USWCL as part of a consortium grant to the University of Arizona. Tests will be initiated in the fall of 2000 and spring of 2001 to study the effects of planting date, plant population, irrigation level, fertility, harvest time, post-harvest/pre-chipping storage conditions, cutting height, and regrowth on latex, seed, and plant growth traits. A cooperative yield test will be established for evaluating promising lines from the breeding program for release and new populations for making selections will be developed. These studies will involve close cooperative work with scientists at the various locations involved in guayule research.

**COOPERATORS:** D.T. Ray and D. Stumpf, Plant Science Department., The University of Arizona, Tucson AZ; M.A. Foster, Texas Agricultural Experiment Station, Texas A&M University, Pecos TX; K. Cornish, USDA-ARS-PWA-WRRC, Albany CA; F.J. Adamsen and D.J. Hunsaker, USWCL, Phoenix AZ.

**Table 1.** Plant stands, height, width, and height/width ratio for 22 guayule lines grown at Maricopa Agricultural Center, Arizona, USA in 1996 and 1997.

Line	Stand 1996 (%)	Stand 1997 (%)	Stand (1996- 1997)	Height 1996 (mm)	Height 1997 (mm)	Height (1997- 1996)	Width (1997) (mm)	Height/ Width
11591	97.00	96.25	0.75	336.50	<b>547.30</b>	<b>210.80</b>	461.00	1.19
N565	80.00	79.25	0.75	250.50	418.00	167.50	436.80	<i>0.96</i>
G1-10	91.25	89.75	1.50	<i>239.50</i>	371.30	131.80	313.50	<b>1.20</b>
G1-16	86.00	79.00	7.00	290.80	431.30	140.50	398.30	1.09
G7-14	<b>99.25</b> <sup>1</sup>	<b>98.50</b>	0.75	<b>405.80</b>	520.50	114.80	458.80	1.13
N6-2	84.50	77.50	7.00	243.00	352.50	109.50	312.50	1.14
N6-3	91.50	86.25	5.25	269.50	388.80	119.30	347.50	1.12
N7-2	75.00	72.50	2.50	311.80	489.30	177.50	444.80	1.10
N7-5	79.75	72.75	7.00	240.30	<i>339.50</i>	99.20	315.50	1.12
N8-1	61.00	58.00	3.00	261.80	427.30	165.50	389.80	1.10
N8-5	75.25	74.50	0.75	<i>238.30</i>	351.30	113.00	321.80	1.10
N8-10	90.75	88.50	2.25	270.30	422.00	151.80	387.00	1.09
N9-3	94.00	90.00	4.00	292.50	465.30	172.80	415.00	1.12
N9-4	61.00	61.75	<i>-0.75</i>	319.30	510.80	191.50	<b>473.00</b>	1.08
N12-18	87.75	80.50	<b>7.25</b>	274.00	402.80	129.50	355.80	1.14
N13-1	83.00	82.25	0.75	299.80	468.00	168.30	420.80	1.11
O16-1	82.25	80.50	1.75	291.50	480.50	189.00	431.80	1.11
P3-11	95.50	92.50	3.00	306.00	430.00	124.00	380.80	1.13
P10-3	<i>56.50</i>	<i>56.50</i>	0.00	250.30	404.80	154.50	371.00	1.09
P10-4	97.00	91.00	6.00	275.50	345.50	<i>70.00</i>	<i>288.50</i>	<b>1.20</b>
P10-5	86.00	82.25	3.75	242.00	367.80	125.80	308.50	<b>1.20</b>
P11-1	84.50	78.25	6.25	247.30	380.80	133.50	337.80	1.13
LSD	16.65	18.34	6.00	51.20	63.70	45.90	62.50	0.10

<sup>1</sup> Numbers in bold are the largest values for the column and numbers in italics are the lowest values for the column.

**Table 2.** Latex content, latex yield, plant wet weight, plant dry weight, chipping loss, and plant biomass of 22 guayule lines grown at Maricopa Agricultural Center, Arizona, USA in 1998.

Line	Wet weight (kg)	Dry weight (kg)	Chip weight (kg)	Chip loss (%)	Plant biomass (g/m <sup>2</sup> )	Latex content (%)	Latex plant (g)	Latex Yield (g/m <sup>2</sup> )
11591	1.91	1.18	1.57	19.48	1626	2.36	27.95	38.68
N565	2.00	1.23	1.66	15.90	1706	3.09	35.03	48.47
G1-10	1.32	1.02	0.97	27.55	1408	3.24	33.41	46.24
G1-16	<b>2.70</b>	1.60	2.18	20.23	2214	<i>2.19</i>	35.81	49.56
G7-14	1.72	0.99	1.25	<b>28.03</b>	1363	2.26	<i>22.16</i>	<i>30.66</i>
N6-2	1.31	0.77	1.05	20.43	1059	3.49	27.45	38.00
N6-3	1.55	0.91	1.19	24.10	1263	3.54	31.82	44.04
N7-2	1.85	1.06	1.55	16.68	1470	2.88	29.85	41.31
N7-5	1.33	0.76	1.02	23.65	1052	3.55	26.79	37.07
N8-1	2.20	1.28	1.83	17.25	1775	3.47	45.80	63.38
N8-5	1.36	0.82	1.00	26.63	1128	4.01	32.74	45.30
N8-10	2.43	1.51	1.98	18.10	2090	3.41	49.93	69.09
N9-3	2.64	<b>1.63</b>	<b>2.27</b>	14.83	<b>2259</b>	3.57	<b>60.34</b>	<b>83.08</b>
N9-4	1.59	0.97	1.22	23.48	1339	3.91	37.67	52.13
N12-18	1.41	0.83	1.10	22.35	1149	3.46	28.74	39.78
N13-1	2.29	1.38	1.84	<i>14.80</i>	1910	3.30	44.49	61.57
O16-1	1.76	1.00	1.33	24.80	1387	3.26	32.30	44.69
P3-11	1.48	0.92	1.09	27.58	1270	4.07	38.28	52.98
P10-3	2.13	1.30	1.80	15.80	1799	3.01	39.20	54.25
P10-4	<i>1.00</i>	<i>0.60</i>	<i>0.73</i>	26.08	<i>830</i>	<b>4.22</b>	25.28	34.99
P10-5	1.44	0.88	1.17	19.60	1221	2.84	26.23	36.30
P11-1	1.58	0.93	1.17	24.89	1287	3.68	34.34	47.52
LSD	0.75	0.50	0.68	9.21	686	0.98	19.03	26.34

<sup>1</sup> Numbers in bold are the largest values for the column and numbers in italics are the lowest values for the column.

## BREEDING IMPROVEMENTS OF LESQUERELLA

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**PROBLEM:** Seed oil yields of *Lesquerella fendleri* (Gray) Wats., *Brassicaceae*, a potential oilseed crop native to the Southwestern United States, cannot yet compete with similar imported oilseeds. The seed oil from lesquerella contains hydroxy fatty acids (HFA), comparable to castor. Imports of castor oil and derivatives amount to more than 65,000 tons per year at a value exceeding \$100 million per year. Unique properties of lesquerella oil along with coproducts are promising for commercialization if yields are improved.

Other species of *Lesquerella* produce higher quantities of HFA than *L. fendleri*, but none are as productive in seed yield. There are more than 70 species from the western half of the U.S. that do not cross-pollinate in the wild. Traits from these species could be incorporated into *L. fendleri* to improve yields. There is also a high amount of diversity within *L. fendleri* that could be utilized for plant improvements. Public releases of seed have been made in the past by this laboratory with higher oil and lesquerolic acid contents and reduced oil pigmentation.

Only limited amounts of seed from germplasm collections are able to be obtained from the wild. Seed increases, evaluation, and passport information are necessary to utilize these accessions successfully in our breeding program. It is also necessary to make seed available to other researchers through the National Plant Germplasm System.

**APPROACH:** Hybrids were produced between *L. fendleri* and one of four other species from greenhouse controlled crosses (Table 1). These species were chosen based on a higher HFA content compared to *L. fendleri*. Embryo rescue was necessary since seeds did not form from the crosses. Some plants resulting from these crosses were sterile, possibly due to some incongruity between the two species. Fertility was restored by chromosome doubling using the chemical colchicine. The order of our procedures to obtain plants for greenhouse crossing was embryo rescue, shoot culture, colchicine treatment, and root culture.

Half-sib selections for high oil content were planted at Maricopa Agricultural Center and re-selected for both high oil and seed yield. The number of mass selected individuals was increased this year from 500 to 1300 plants to obtain more variability. The selections originated from a previously released line, WCL-LY2.

Seeds originating from a past collection trip in Mexico were field or greenhouse grown at the U. S. Water Conservation Laboratory (USWCL), Phoenix, Arizona, for seed increase and evaluation. When only limited seed quantities were available, seeds were started in the greenhouse in October and transplanted into the field in November and December. When plants began to flower, screen cages were placed over individual field plots and supplied with housefly larvae which then emerged for pollination. The pollinators within cages prevented cross pollination with other accessions. Plants were also grown in greenhouses if the accession of a species was not adaptable to an Arizona climate. Flies were also placed in the greenhouses on a weekly basis during the flowering period.

Plant growth measurements were taken throughout the season; and after harvest, seeds from each accession were analyzed for oil content and composition.

**FINDINGS:** F<sub>1</sub> interspecific hybrids had traits such as leaf shape, trichomes, stem thickness, and flower color that were intermediate of the parental plants. Although parental crosses were done via bud pollinations and siliques formed, less than 0.1% seed amounts were produced. Embryo rescue increased the number to 75%, depending on the cross. Colchicine applied at a rate of 0.1% to shoot meristems and cultured for two days was successful in producing fertile hybrids. When *L. fendleri* was crossed to one of the four species, the F<sub>1</sub> hybrid had the same HFA content as *L. fendleri* maternal parent instead of a mid-parent value. When the reciprocal was crossed, the hybrid had the same HFA content as the other species used as the maternal parent. This indicated that HFA content is maternally inherited.

**Table 1.** Chromosome number, oil, lesquerolic, and auricolic acids of *L. fendleri* and four other species used for interspecific crosses.

Lesquerella species	<i>n</i> = x	Oil content (%)	Lesquerolic acid (C20-1OH) (%)	Auricolic acid (C20-2OH) (%)
<i>fendleri</i>	6	23.6	50.2	trace
<i>lindheimeri</i>	6	21.6	81.7	0.35
<i>pallida</i>	6	na	81.4	3.68
<i>gracillis</i>	6	28.9	68.8	trace
<i>auriculata</i>	8	33	8.1	17.4

Seed oil content averaged 29.0% for the 1300 randomly selected plants. Unselected plants averaged 23.6% for oil contents. The top 150 plants were selected from this population and bulked together for next season planting. This population averaged 34.09% for oil content.

Two new germplasm lines developed here were released to the public this year. WCL-LY2 has high oil content and seed yield compared to the previous released line and WCL-SL1 is salt tolerant.

Forty-eight accessions from 12 species were increased this year at the USWCL. Some of these are shown in Table 2. A single plant of *L. fendleri* growing in the evaluation plots, A4005, segregated for cream-colored flowers. This has never been reported for this species. All other flowers are yellow. It could be a useful phenotypic marker for breeding.

Following harvest, seeds of increased accessions were sent to the ARS Curator in Parlier, California, to be entered in the National Plant Germplasm System. A service contract with a cooperator in Mexico provided more accessions from areas that were not able to be collected last year because of lack of seed on plants, or there was not enough rain for plants to reach the full flowering cycle. Seed was obtained from these accessions and other localities not previously visited.

**Table 2.** Results of evaluation of some of the *Lesquerella* species increased and evaluated at the

USWCL, 1999-2000.

	Collecti on number	Species	Date of 1st flower	1000 Seed wt. (g)	Oil (%)	Hydroxy fatty acid (%)	Seeds per silique	Plant height (cm)	Plant width (cm)
1	A3342	<i>argyraea</i>	12/09	1.30	18.39	57.84	17.75		
2	A4004	<i>argyraea</i>	01/16	0.51	19.29	55.48	18.7	18.4	43.5
3	A4014	<i>argyraea</i>	01/25	0.50	20.26	53.18	8.7	26.2	51.6
4	A4030	<i>argyraea</i>	12/27	1.05	17.19	59.05	10.7	10.7	57.1
5	A863	<i>argyraea</i>	03/30	1.00	26.44	24.64			
6	A2401	<i>douglasii</i>	01/18	1.38	19.73	43	2.16		
7	A2402	<i>douglasii</i>	01/19	1.20	9.83	38.05	1.12		
8	A2403	<i>douglasii</i>	01/18			48.04	1.16		
9	A3343	<i>fendleri</i>	01/31		17.64	51.54	3.12		
10	A4001	<i>fendleri</i>	01/12	0.69	21.61	55.48	11.7	22.8	46
11	A4002	<i>fendleri</i>	01/31	0.56	24.82	54.47	17.7	23.9	45.5
12	A4003	<i>fendleri</i>	02/11	0.58		55.07	13.7	23.8	65.1
13	A4005	<i>fendleri</i>	01/30	0.71	22.7	55.33	13.4	25.9	51.7
14	A4006	<i>fendleri</i>	01/31	0.57	22.69	55.86	14.3	29.3	73
15	A4007	<i>fendleri</i>	01/19	0.53	25.1	55.7	16.2	26.5	59.4
16	A4015	<i>fendleri</i>	03/09	0.70	21.93	52.28	7.6	18.6	27
17	A4016	<i>fendleri</i>	02/17	0.61	20.23	53.05	8.7	18.1	22.7
18	A4024	<i>fendleri</i>	01/27	0.63	22.49	56.58	16.7	13.4	33.6
19	A4027	<i>fendleri</i>	03/20	0.67	19.99		7	14.3	22.4
20	A2217	<i>lasiocarpa</i>	12/10	0.69	27.51	31.51	20.4		
21	A2217	<i>lasiocarpa</i>	01/31	0.81	26.10	53.25	22.5		
22	A2228	<i>lasiocarpa</i>	01/25	0.46	23.61	50.26	20.7		
23	A2232	<i>lindheimeri</i>	12/21	1.00		83.24	12.1		
24	A3344	<i>mexicana</i>	03/20	1.22	12.89	56.21			
25	A1859	<i>pinetorum</i>	01/31			9.53	1.9		

26	A1853	<i>purpurea</i>	01/08			27.21	1.98		
27	A4020	<i>schaffneri</i>	02/24					6.7	18.4
28	A640	<i>wardii</i>	01/06	1.58	18.08	33.11	1.98		
29	AS741	<i>wardii</i>	12/20	1.58	16.21	19.19	4.74		

**INTERPRETATION:** These are the first confirmed interspecific hybrids of *Lesquerella* species native to the Western U.S. Since hybrids had the same oil profile as the maternal parent, species other than *L. fendleri* with high HFA contents were used. Hybrids have HFA contents of more than 80%. Many of the other traits from these species are not desirable and will need to be bred out. This will be done through backcrossing the hybrid with *L. fendleri* over several generations until the hybrid has most characteristics of *L. fendleri* except for the HFA contents. This has the potential to reduce the cost of the seed oil drastically from about \$3 to \$1 per pound and to compete with castor effectively in the marketplace.

The 150 selected plants for oil content and seed yields had some plants with oil contents above 39%. This is the first year we have seen plants above 37%. This may be due to recombination of favorable alleles and/or a higher probability of finding those plants with the larger selection of plants. Over an eight-year period, there has been a 10% increase in oil content. With larger sample sizes, we may be able to reach 40% within five years.

Breeding *L. fendleri* with wild relatives may yield offspring that bear bigger seeds with more oil and higher amounts of hydroxy fatty acid. It may also expand the growing region outside the Southwest U.S. Special care must be taken to assure that seed is increased without contamination from other accessions, evaluated to obtain usable information about the accession, and properly handled from harvest to storage. The seed deposited into National Plant Germplasm System benefits researchers nationally and internationally. It also has a long-term benefit to our breeding program.

**FUTURE PLANS:** Interspecific hybrids are being backcrossed to *L. fendleri*. High oil lines will be used as the donor pollen parents. We have some hybrid plants that have already been backcrossed once ( $BC_1F_1$ ) and will be backcrossed again this season. Others will be backcrossed for the first time. Internal transcribed spacers (ITS) molecular markers are being used to confirm hybridity and are especially useful to distinguish at the species level. These utilize the 18S - 26S nuclear ribosomal DNA region. Taxonomic information, such as leaf trichome descriptions, number of ovules, and flower petal length, is also being collected. Chromosome counts of colchicine hybrids have started.

The selection within *L. fendleri* for high oil will continue with increased sample numbers. Further germplasm releases are anticipated. Seed increase and evaluation of seed sent this year from Mexico will be evaluated this coming year.

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